Armed Forces College of Medicine

AFCM

Cardio-Pulmonary Physiology

Lecture 23: Cardiovascular Responses to Exercise

Exercise Physiology

Cardiovascular

Responses to Exercise

Presented By

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INTENDED LEARNING OBJECTIVES (ILO

By the end of this lecture the student will be able to:

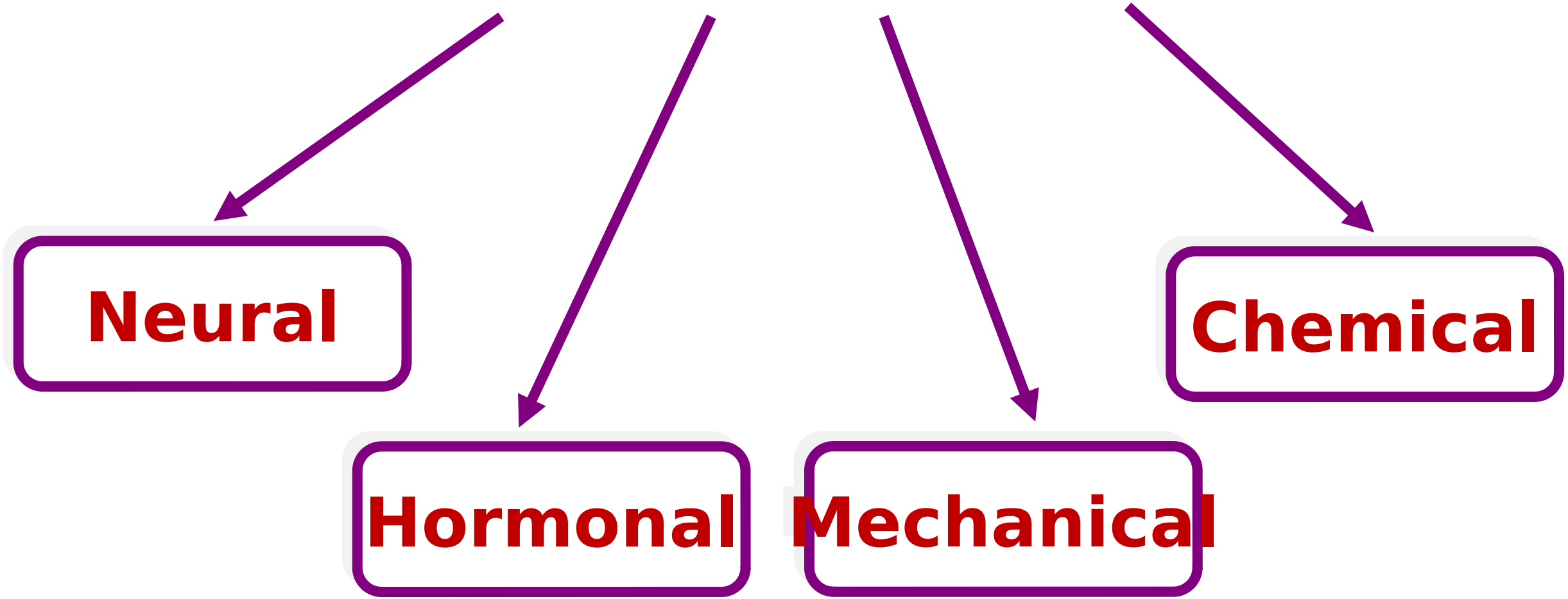
1. Describe the effects of muscular exercise on the cardiovascular system.
2. Describe the CVS response to acute exercise in athletes and non-athletes.
3. Describe the CVS response to chronic exercise.
4. Apply the knowledge and skills acquired by studying this

Skeletal Muscle Blood Flow

Skeletal muscle constitute 40 – 45 % of body weight

	Rest	Exercise
CO	15 %	70 – 80 %
Blood flow	3 – 4 ml/min/100gm	100 – 200 ml/min/100gm
Capillary	10 – 20 % open	All open

Regulation of Skeletal Muscle Blood Flow



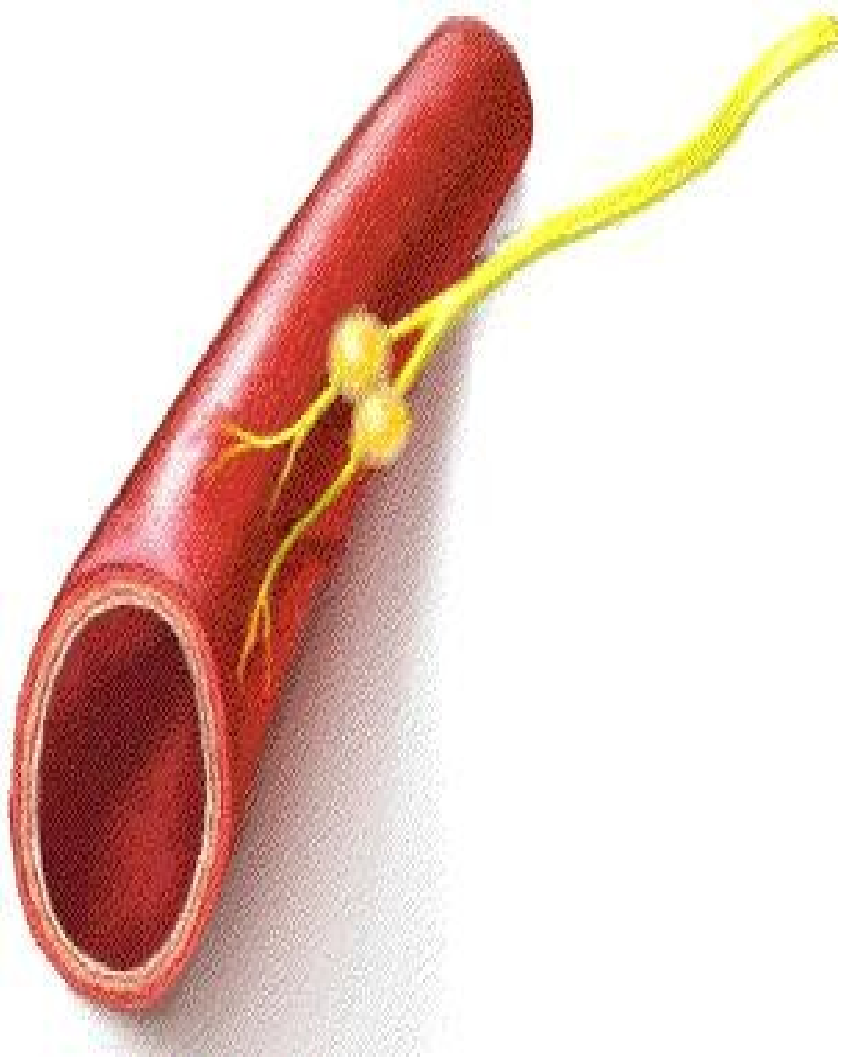
A) Neural Regulation

1) Sympathetic nor-adrenergi

- Has tonic activity
- Act on α_1-receptors VC

2) Sympathetic cholinergic fil

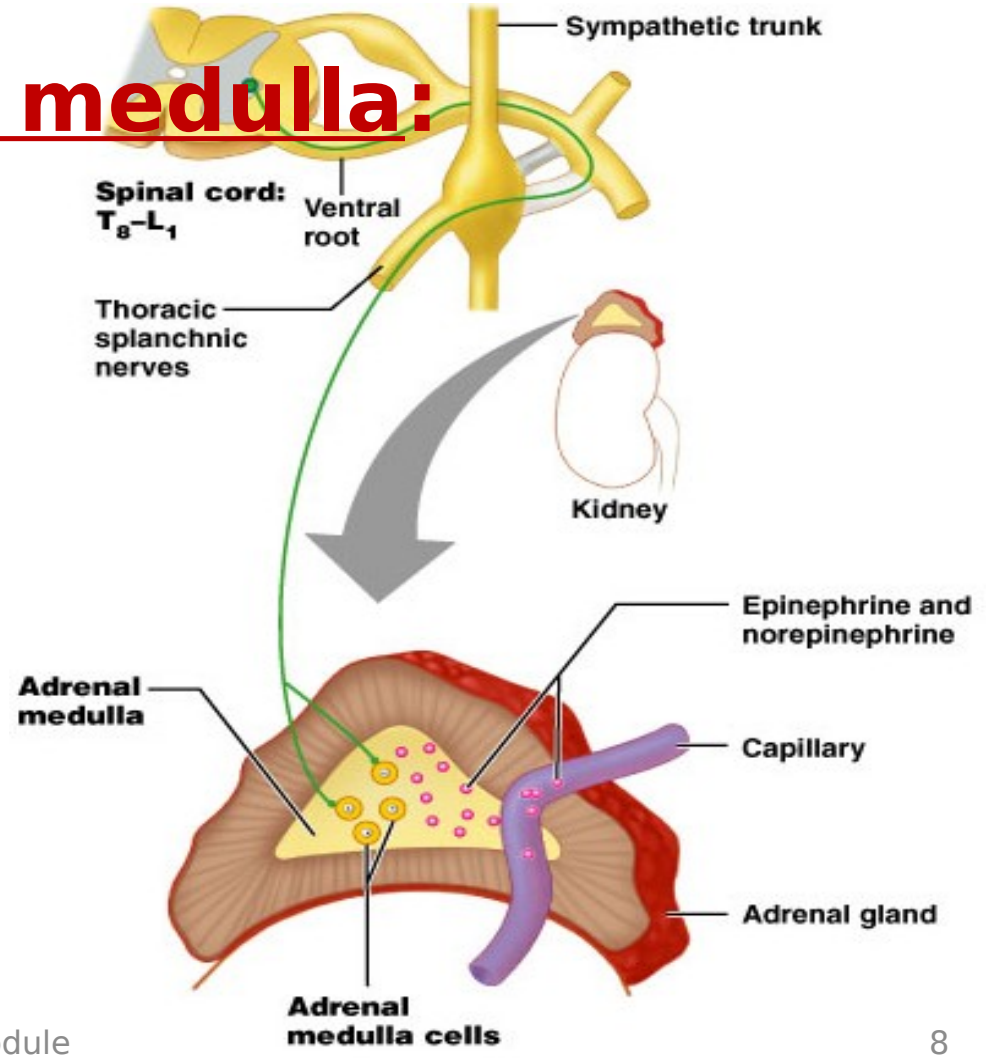
- At the start of exercise
- Originate at cerebral cortex
- Act on M_3-receptors VD



B) Hormonal Regulation

Epinephrine from adrenal medulla:

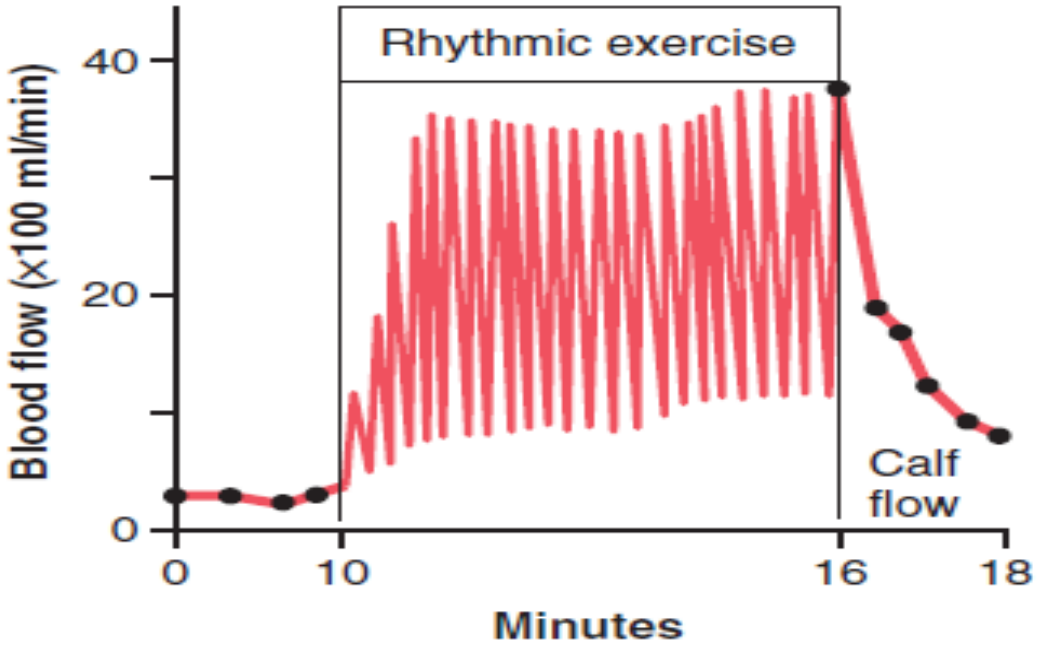
- During exercise
- Act on β_2-receptors VD



C) Mechanical Regulation

Effect of muscle contraction:

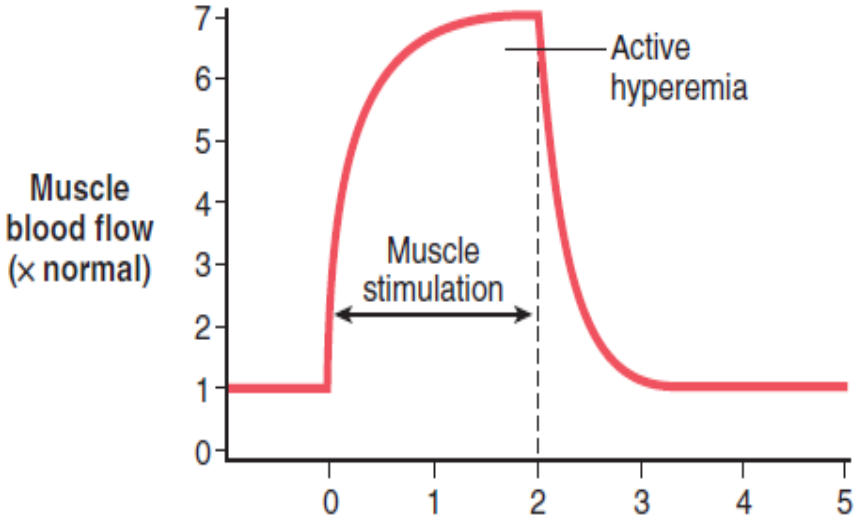
- During contraction □ ↓ Flow
- During relaxation □ ↑ F

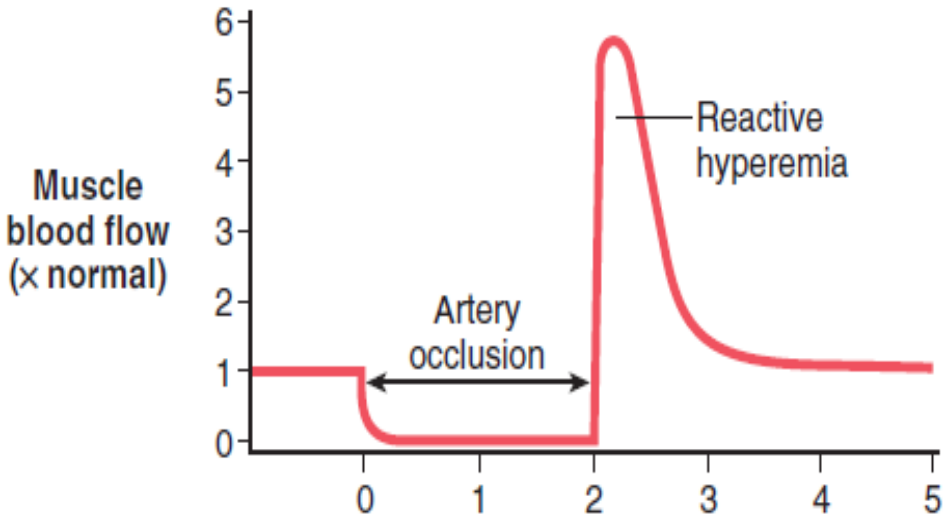


D) Chemical Regulation

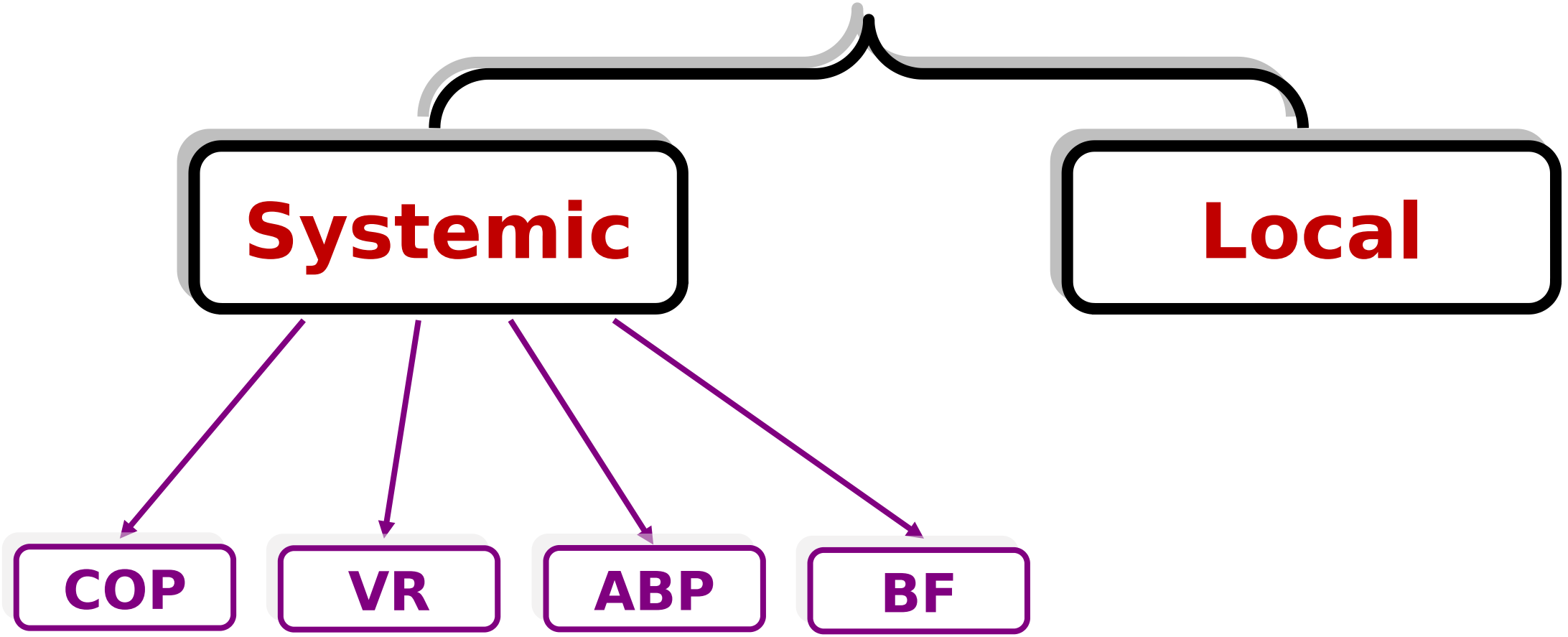
It is local mechanism:

- Due to release of VD metabolites, ↑ temperature
- It is in the form of ***Active*** or ***Re-active*** Hyperemia

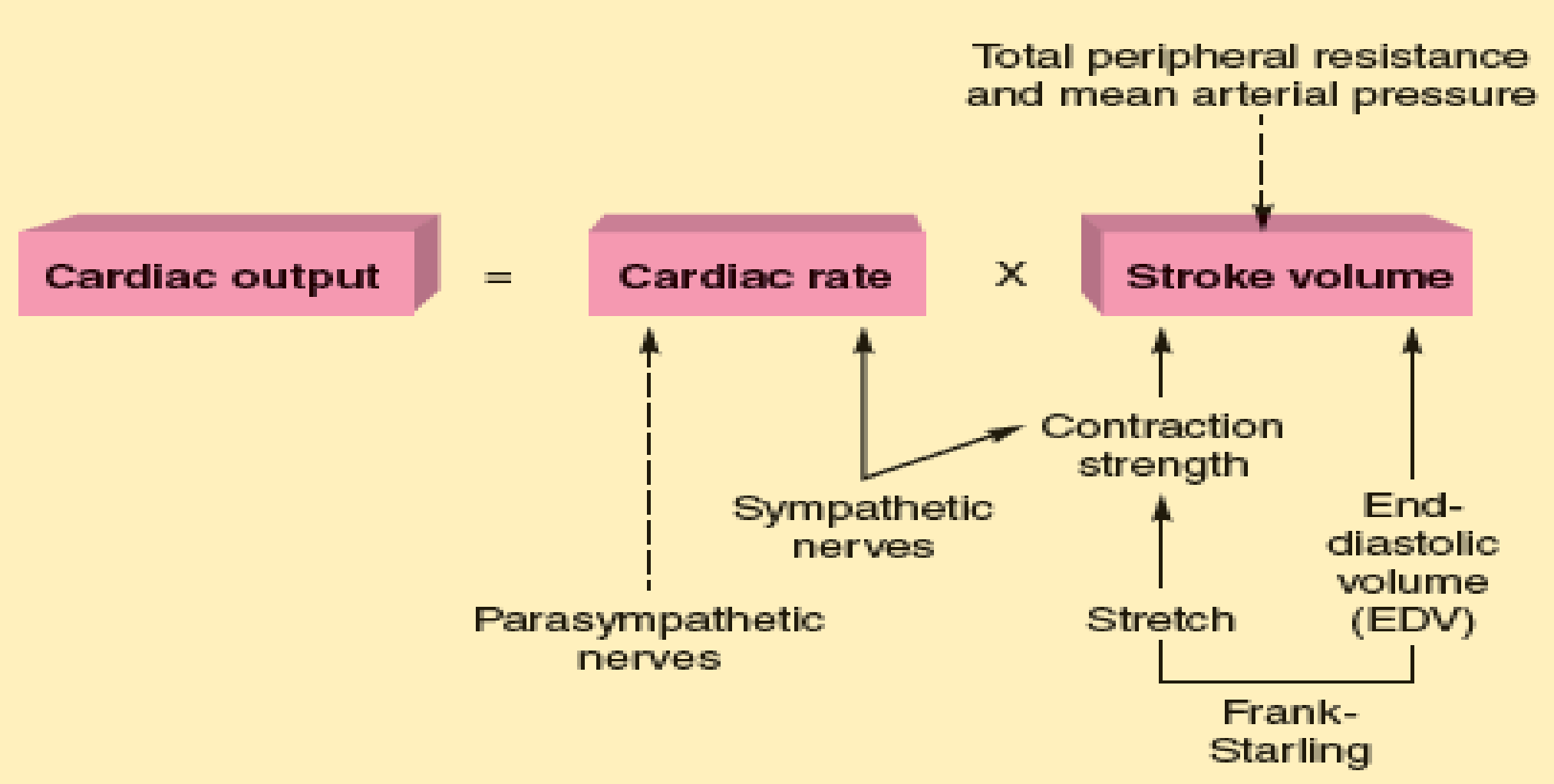




Circulatory Responses to Exercise



A) Increased Cardiac Output



A) Increased Cardiac Output

Cardiac output is increased up to 35 L/min, due to both HR & SV

1- Increased heart rate (HR):

a) Psychic stimuli

b) Sympathetic + vagal tone

c) Circulating adrenaline

d) Body temperature

e) Venous return (VR)

f) Impulses from active muscles

g) Impulses from chemoreceptors

A) Increased Cardiac Output

2- Increased stroke volume (SV):

a) ↑ Sympathetic activity

b) Circulating adrenaline

c) ↑ Venous return (VR) → ↑ Pre-load

d) Peripheral VD → ↓ After-load muscles

B) Increased Venous Return

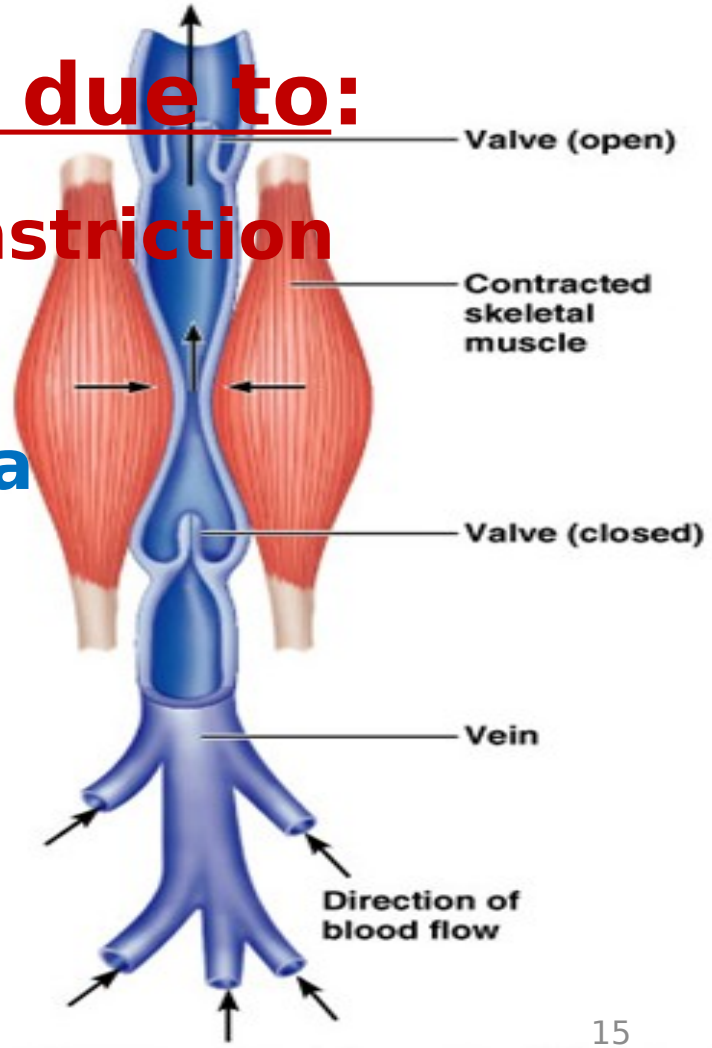
Venous return (VR) is increased due to:

a) ↑ Sympathetic activity → Venoconstriction

b) Mobilization of blood from viscera

c) ↑ Thoracic pump activity

d) ↑ Skeletal muscle pump activity



C) Increased Arterial Blood Pressu

Arterial blood pressure (ABP) is Increased due to:

a) Sympathetic activity → Arteriolar VC

b) Pumping activity of the heart

c) Venous return

D) Re-distribution of Blood Flow

Blood Flow	Level
Coronary	Increased
Cerebral	Constant
Pulmonary	Increased
Visceral	Decreased
Skeletal	Increased
Cutaneous	Decreased (Temperature □□)
Renal	Decreased

Local Changes in the Active Muscl

1- Increased muscle blood flow :

a) ↑ VD metabolites (Adenosine, K^+, CO_2, H^+)

b) Sympathetic VD fibers (at the beginning of exercise)

c) Circulating adrenaline

d) ↑ Temperature within the muscle

2- Capillaries:

a) Dilatation

b) Opening of more capillaries

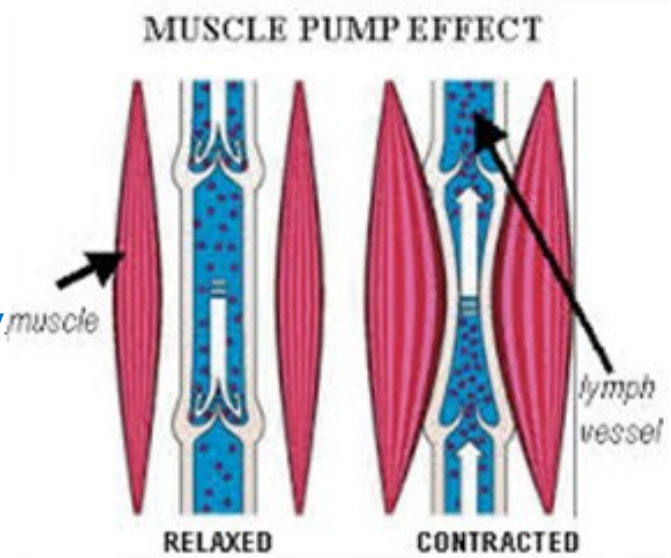
Local Changes in the Active Musc

3- Increased lymph flow :

a) ↑ Thoracic pump activity

b) ↑ Skeletal muscle pump activity

c) Arterial pulsation



4- Increased oxygen uptake due to:

a) ↑ muscle blood flow

b) Shift of O_2–HB dissociation curve to the right

Adaptation to Exercise Training

1- Cardiac output:

- Resting cardiac output of athletic person is the same as normal

a) ⇔ Resting stroke volume

- **Increase in ventricular volume**
- **Increase in ventricular wall thickness**

b) ⇔ Resting heart rate

- **Increase vagal tone**

Adaptation to Exercise Training

2- Cardiac hypertrophy:

- Due to increase synthesis of proteins
  - ➢ ↑ Force of ventricular contraction

3- Cardiac reserve:

- The role of training is to increase cardiac reserve

a) Short-term mechanism
  - ➢ Increase heart rate & stroke volume

b) Long-term mechanism
  - ➢ Dilatation & hypertrophy

Adaptation to Exercise Training

4- Coronary blood vessels:

- Training improves coronary vascular bed

a) ↑ Density of coronary capillaries

b) ↑ Production on nitric oxide

b) ↓ Compression of the coronary vessels in systole

5- Cardiac vascular diseases:

- Training reduces incidence and severity of MI

Question Time

Question 1

Cardiovascular responses to exercise include an increase of the followings EXCEPT:

a) Cardiac output.

b) Heart rate.

c) Total peripheral resistance.

d) Oxygen consumption.

e) Systolic blood pressure.

Question 2

Ventricular hypertrophy in marathon's runner is associated with:

a) Decreased force of ventricular contraction.

b) Thickening of the wall.

c) Normal level of basal inotropic state.

e) Increased end-systolic volume (ESV).

d) All of the above.

I  exercise

SUGGESTED TEXTBOOKS

1. **Guyton and Hall**
   Text book of Medical Physiology, 13th Edition (2016)
2. **Ganong's**
   Review of Medical Physiology, 24rd Edition (2012)
3. **Fox**
   Human Physiology, 14th Edition (2016)
4. **Sherwood**
   Human Physiology .. From Cells to Systems, 9th Edition (2016)


THANK YOU